OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS [OLMSA]

Research on the International Space Station

Prof. Dava Newman for

16.423J/HST515J

Many thanks to:

Dr. Arnauld E. Nicogossian, MD

Associate Administrator

NASA Office of Life & Microgravity Sciences & Applications

September 2000

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Why Space Station?

Station is an international cooperative research platform

To Provide…

…..an advanced testbed for technology & human exploration

…..a state-of-the-art research facility on which to study gravity's effects on physical, chemical, & biological systems

…..a commercial platform for space research & development

To Learn…

…..how to live, explore, and work productively in space

…..how to use the attributes of space to enhance products & processes for Earth

Space Station & Exploration

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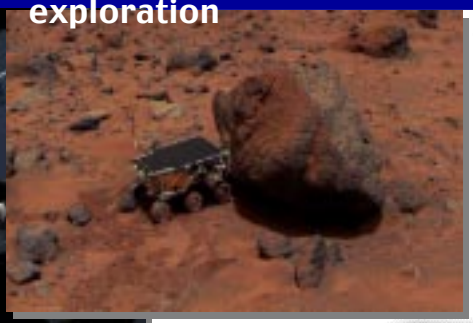
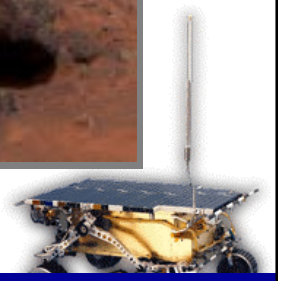
Station is a testbed for solar system exploration



The Martian Surface



The Mars Transhab

Sojourner Rover Exploration Technology

The First Steps

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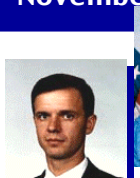
The first Station element launched on 20 November 1998

First Station ingress, 10 Dec. 1998



William (Bill) Shepherd, Commander

Yuri Pavlovich Gidzenko, Soyuz Commander

Sergei K. Krikalev, Flight Engineer

First Crew 01/00

Yuri Usachev; Expedition Commander

Susan J. Helms

James S. Voss

Second Crew 4/00

What is Space Station?

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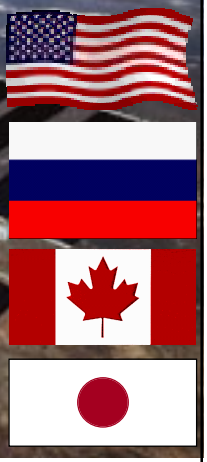
A means to link research communities in space & on Earth

Major Research Capability

- Biomedical Research & Countermeasures Development
- Gravitational Biology & Ecology (under variable gravity)
- Materials Science
- Biotechnology
- Fluids & Combustion
- Human-machine Interfaces and Advanced Life Support
- Low Temperature µg Physics
- Earth Observation & Space Science
- Multipurpose EXPRESS Racks & Pallets

U.S. Lab 03/00

- **At least 4 International Laboratories**
- **External Attached Payload Sites**
- **Multipurpose EXPRESS Racks & Pallets**



esa

What is Space Station?

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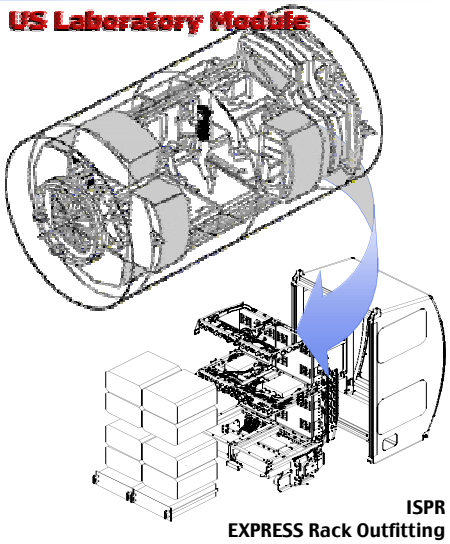
Resources

- Power
- Thermal Control
- Data Handling & Communications (Telescience)
  - On Board
  - From the Ground
- Microgravity 10^{-6}
- Gaseous N_2, O_2, CO_2, Ar, He
- Vacuum Exposure & Vent
- Human Intervention
- Observational Windows



ISPR
EXPRESS Rack Outfitting

Gravitational Biology

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What is the role of gravity in the evolution, development, structure, and function of life, and as a result, life's interactions

- Through what mechanisms do plants & animals sense and respond to gravity, and what is the gravitational threshold for this perception to occur?*
- What role does gravity play in the development of gravity-sensing vestibular systems in animals?*
- Are there developmental processes in plants and animals that depend upon gravitational stimuli?*

*Questions derived from Space Studies Board, National Research Council, *A Strategy for Research in Space Biology and Medicine in the New Century*, 1998

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Biomedical Res. & Adv. Human Support Tech.

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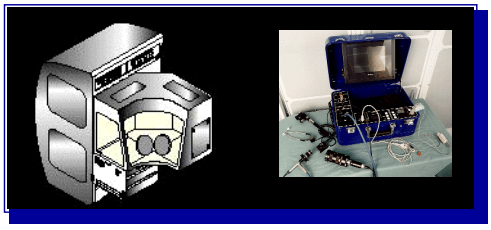
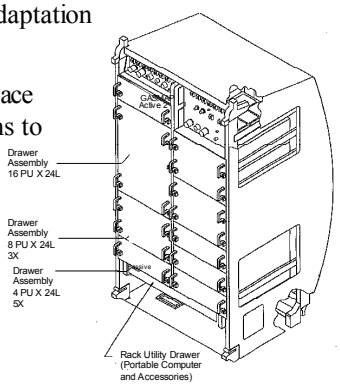
What is required to assure the health, safety and productivity for humans living & working in space?

- How do humans adapt to space flight conditions, and how can we best facilitate that adaptation & readaptation to a gravity environment?
- What are the hazards to humans posed by the space environment, and what are the optimum solutions to minimize these hazards?





Human Research Facility Rack

Biotechnology

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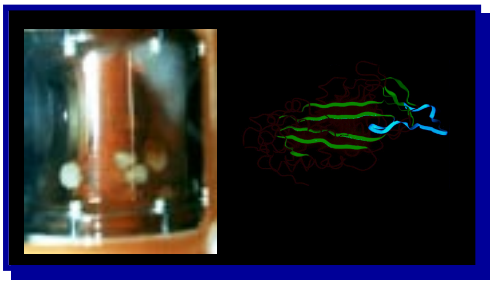
What are the controlling mechanisms in cellular aggregation and differentiation which would allow *in vitro* growth of cells, organisms, organs, and other biologically interesting structures?

- How does gravity affect protein crystallization & growth, and what factors are responsible for increasing the structural resolution of certain protein crystals grown in µg?*
- Can µg cell culturing technology improve the limits of ground-based tissue engineering?



*Questions derived from Space Studies Board, National Research Council, *Microgravity Research Opportunities for the 1990s*, 1995

Fluid Physics & Combustion Science

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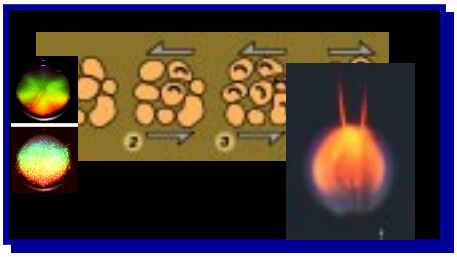
What is the most effective energy conversion process involving combustion, and how can we achieve that?

What are the fundamental forces affecting fluid behavior?

- How do dominant forces in microgravity, such as surface tension gradient-driven flows, affect fluid behavior, and how do magnetic & electrical forces affect fluid transport in variable gravity environments?*
- How do flames behave in variable gravity environments, and how is this dependent upon atmospheric & fuel composition?*
- What are the forces governing soot formation in combustion processes?



*Questions derived from Space Studies Board, National Research Council, *Microgravity Research Opportunities for the 1990s*, 1995

Materials Research & Fundamental Physics

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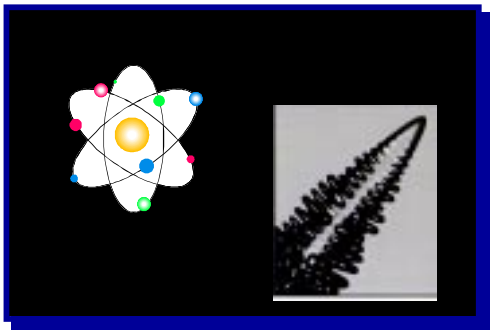
What is the optimum relationship between the process used to form a material and its resultant properties, and how can we achieve this in space and on the ground?

How can the space environment help us obtain fundamental physical measurements of the highest accuracy?

- How do various transport phenomena affect the formation and quality of selected materials?*
- How can containerless processing best enhance desirable qualities in selected materials? *

*Questions derived from Space Studies Board, National Research Council, *Microgravity Research Opportunities for the 1990s*, 1995



Engineering Research & Technology Development

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What technologies are best suited for long-duration missions of human space exploration?

- How do large structures behave in space?*
- How does the space environment affect the properties and performance of selected materials?*
- What are the optimum technologies in solar dynamic power generation in terms of efficiency, mass, and size?*
- How do we maximize the reliability and usefulness of deployable structures for space exploration & development?

*Questions derived from Aeronautics & Space Engineering Board, National Research Council, *Engineering Research & Technology Development on the Space Station*, 1996

Biologically-based Technologies for Exploration

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Smart Materials & Structures

- Anticipatory
- Collaborative
- Curious
- Self-modeling
- Adaptive
- Self-repairing
- Portable
- Sensor-fusion & sensory-guided motor control

AERCam

Human-centered Systems

- Cognitive task analysis research
- Innovative human-machine interfaces
- Portable digital assistants & wearable computing research

Electronic Nose Component

*Areas of emphasis derived from Space Studies Board, National Research Council, *Report of the Workshop on Biologically-based Technologies for Space Exploration*, 1998

Space Science

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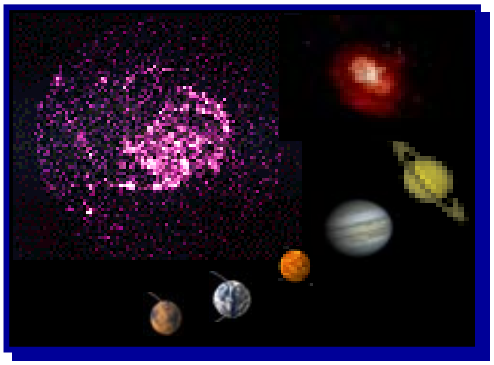
How did the Universe, galaxies, stars, and planets form & evolve?*

- What is the morphology of the local space physics & Earth magnetospheric environments?
- What are the sources of cosmic-ray particles, and how are they related to the structure and evolution of the universe?
- What are the source of interplanetary cosmic-dust particles, and what is their linkage to the evolution of the solar system?

*1998 NASA Strategic Plan



Earth Science

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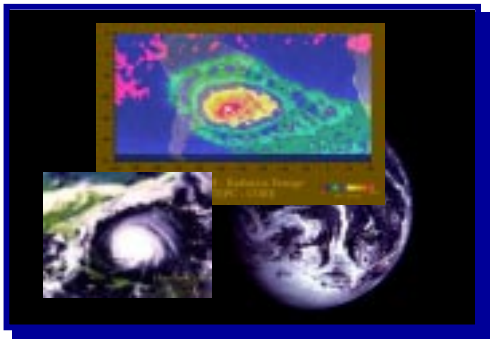
How does the Earth environment change over time, and what are the causes of these changes?*

- What are the nature and extent of land-cover and land-use changes over time?
- How can we better predict natural disasters?
- How does the Earth respond to variations in total solar irradiance?
- How and why are Earth atmospheric constituents changing, and what are the long-term impacts of these changes?

*1998 NASA Strategic Plan



Commercial Research

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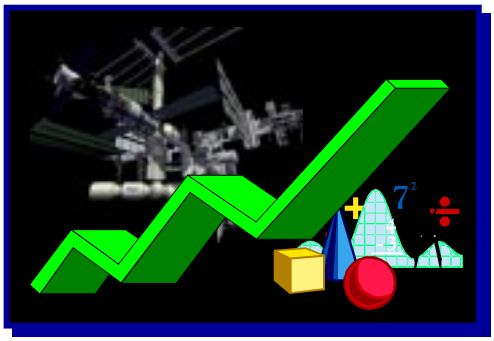
How can we best use the results of space research to improve products and processes on Earth?

- Can microgravity research facilitate the reduction of defects in polymer materials?
- Can microgravity research help us to improve the efficiency of selected agricultural techniques to enhance Earth-based food production?
- How can the Station best facilitate commercial space development?



NASA-sponsored Centers & Research Institutes

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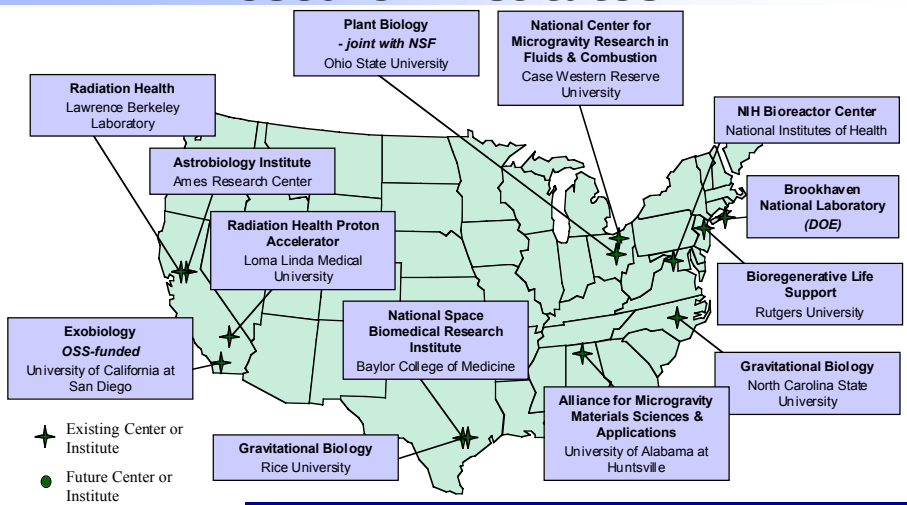

FY 1998 – 775 P.I.s

FY 2000 – 962 P.I.s

FY 2002 -- 1000+ P.I.

Station Telescience

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P.I.'s will be able to interact with their payloads abo Station via *telescience* operations

"P.I. in a Box"

Telescience Support Centers (TSC)

- Geographically dispersed
  - Designated NASA facilities
  - International partner mission control centers
  - Remote locations such as a PI or commercial laboratory
- Download data directly to investigators
- Allow investigators to communicate with their

Telescience Resource Kit (TReK)

- PC-based telemetry & command system
- Networks to TSC or NASA Payload Operations Integration Center
- Allows access to ISS payload and ground-based payload planning and info. mgt. systems

Telescience capabilities enhance the educational potential

Research on the ISS
Collaboration

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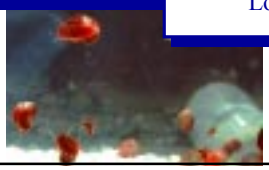
STS-90 & STS-95 are Models of Cooperation

STS-90 – Neurolab

- International Payload
  - Participation by CSA, ESA, CNES, DARA, NASDA
- Interagency Collaboration
  - Cooperation with NIH, NSF, & ONR

STS-95

- International Crew
  - Chiaki Mukai (Japan)
  - Pedro Duque (Spain)
- Multinational payload (ESA, NASDA)
- Interagency cooperation
  - NIH/National Institute on Aging/Baltimore Longitudinal Study on Aging



International AOs and NRAs will broaden Station

The Exploration Vision

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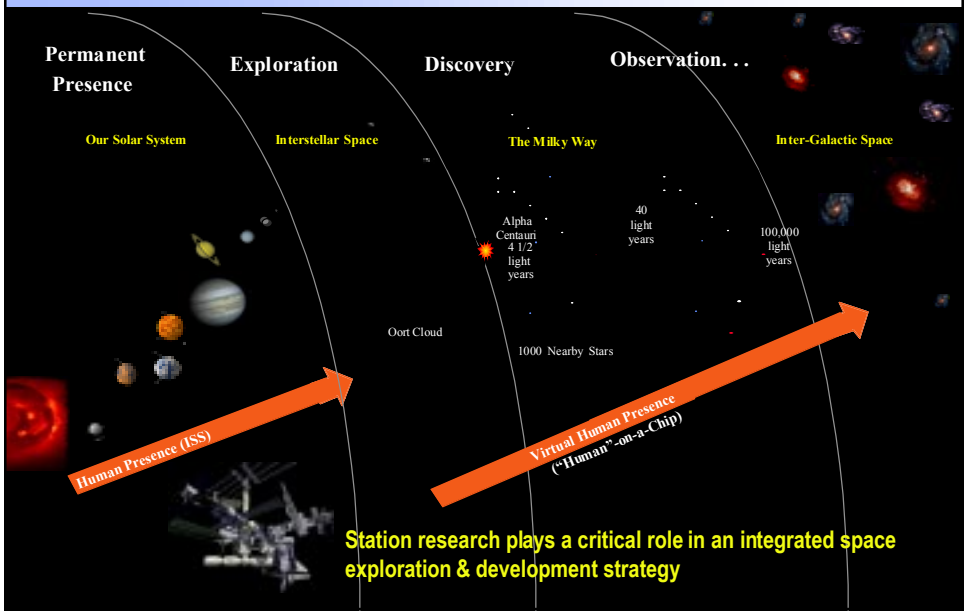

Station research plays a critical role in an integrated space exploration & development strategy

Getting on Board
NASA Research Solicitations

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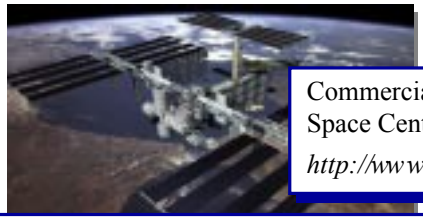
See these web sites for NASA Research Announcements and Announcements of



Commercial users should contact a Commercial Space Center:

http://www.hq.nasa.gov/office/olmsa/spd/index.htm

http://peer1.idi.usra.edu/

life/µg sciences

http://www.earth.nasa.gov/nra/index.html

⊕ sciences

http://www.hq.nasa.gov/office/oss/research.htm

space sciences